INTRAOCULAR LENS FOR RESTORING ACCOMMODATION AND ALLOWS ADJUSTMENT OF OPTICAL POWER

FIELD OF INVENTION

This invention relates to intraocular lenses and, more particularly to a focusable intraocular lens that can restore accommodation for near vision.

BACKGROUND OF THE INVENTION

The normal healthy human eye is capable, by means of the ciliary muscle, of altering the focus of the crystalline lens to focus on distant objects and to focus on near objects as well. This latter capability is known as accommodation and is realized by contraction of the ciliary muscle which causes the lens to assume a more spherical shape, thereby increasing its power. As a person ages, the eye gradually loses its ability to change focus readily, and hence, its ability to accommodate, thereby forcing the individual to resort to reading glasses for close up work. This condition is termed presbyopia.

Loss of accommodation can also occur, drastically, when the crystalline lens of the eye becomes clouded or opaque, commonly referred to as cataract formation, and must be removed and replaced by a plastic or glass intraocular lens. Such intraocular lenses are usually fixed focus lenses, so that accommodation cannot be readily realized. Thus, the patient having an intraocular lens implanted in the eye must resort to corrective glasses for reading or close-up work. In addition, it has proven to be extremely difficult to achieve a desired degree of refraction in such an intraocular lens, the accuracy of achieving the desired refractive outcome following implantation having a standard deviation of approximately one (1.00) diopter. As a consequence, the majority of patients having intraocular implants must resort to spectacles to obtain their best distance vision. In some cases the postoperative refractive error is so large that removal and replacement of the intraocular lens becomes necessary.

There have been numerous attempts to achieve at least some useful degree of accommodation with an intraocular implantation which, for various reasons, fall short of being satisfactory. In U.S. Pat. No. 4,666,446 of Koziol et al., there is shown an intraocular lens having a complex shape for achieving a bi-focal result, the lens being held in place within the eye by arms, i.e., haptic supports, which are attached to the ciliary body or muscle. However, the implant requires the patient to wear spectacles for proper functioning. Another device shown in U.S. Pat. No. 4,944,082 of Richards et al., also utilizes a lens having regions of different focus, or a pair of compound lenses, which are held in place by haptics attached to the ciliary body. In this arrangement, contraction and relaxation of the ciliary muscle causes the haptics to move the lens or lenses, thereby altering the effective focal length. There are numerous other patented arrangements which utilize haptics connected to the ciliary body, or are otherwise connected thereto, such as are shown in U.S. Pat. Nos. 4,932,966 of Christie et al., U.S. Pat. No. 4,888,012 of Horne et al. and U.S. Pat. No. 4,892,543 of Turley, and rely upon the ciliary muscle to achieve the desired alteration in lens focus.

In any arrangement that is connected to the ciliary body, by haptic connection or otherwise, extensive erosion, scarring, and distortion of the ciliary body usually results. Such scarring and distortion leads to a disruption of the local architecture of the ciliary body and thus causes failure of the

small forces to be transmitted to the intraocular lens. Thus, for a successful long-term implant, connection and fixation to the ciliary body is to be avoided if at all possible.

In U.S. Pat. No. 4,842,601 of Smith, there is shown an accommodating intraocular lens that is implanted into and floats within the capsular bag. The lens comprises front and rear flexible walls joined at their edges, which bear against the front and rear (anterior and posterior) inner surfaces of the capsular bag. Thus, when the zonules, the muscle strands joining the ciliary body to the capsular bag, exert a tensional pull on the circumference of the capsular bag, the bag, and hence the intraocular lens, is flattened, thereby changing the index of refraction of the lens. The implantation procedure requires that the capsular bag be intact and undamaged and that the lens itself be dimensioned to remain in place within the bag without attachment thereto. Additionally, the lens must be assembled within the capsular bag and biasing means for imparting an initial shape to the lens must be activated within the capsular bag. Such an implantation is technically quite difficult and risks damaging the capsular bag, inasmuch as most of the operations involved take place with tools which invade the bag. In addition, the Smith arrangement relies upon pressure from the anterior and posterior walls of the capsular bag to deform the lens, which requires that the lens be extremely resilient and deformable. However, the more resilient and soft the lens elements, the more difficult assembly within the capsular bag becomes.

The prior art thus discloses numerous arrangements for accommodating intraocular lenses, none of which is capable of providing an accommodating implant which does not, in one way or another, risk damage to the ciliary body or the capsular bag. In addition, while the prior art does show arrangements for imparting an initial bias or shape to the intraocular lens, in most cases the-focal length, once set, remain fixed except for the accommodation. As pointed out in the foregoing, the post operative refraction error can be as great as one diopter, or even more, necessitating the use of spectacles for the distance vision or in extreme cases, removal and replacement of the intraocular implant.

SUMMARY OF THE INVENTION

The present invention comprises an intraocular lens that can accommodate for near vision and which allows adjustment of its optical power after implantation. The invention further includes the method by which such a lens is implanted within and retained in place by the patient's eye. The implantation does not require the use of haptics or other potentially damaging support means, nor does it rely solely upon pressures exerted by both the anterior and posterior walls of the capsular bag. The structure of the lens and the method of implantation are such that any tool invasion of the capsular bag is minimized, thereby lessening any risk of damage to the bag.

The intraocular lens of the invention, in one preferred embodiment thereof, comprises an anterior accommodating portion and a posterior non-accommodating portion. The accommodating portion, comprises a molded body of a soft, compliant polymer that has a preferred modulus of elasticity and compliance and has, normally, an accommodating shape which it assumes in the absence of other forces. The non-accommodating portion preferably comprises a molded body of a standard hard polymer, or equivalent, that is frequently used in intraocular lenses. In order that the anterior portion may expand and constrict sufficiently to achieve the desired degree of accommodation, the rear wall